Science Visualization

Principles for an emerging animation community to consider

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Science visualization Principles for an emerging animation community to consider

By Peter Vistisen

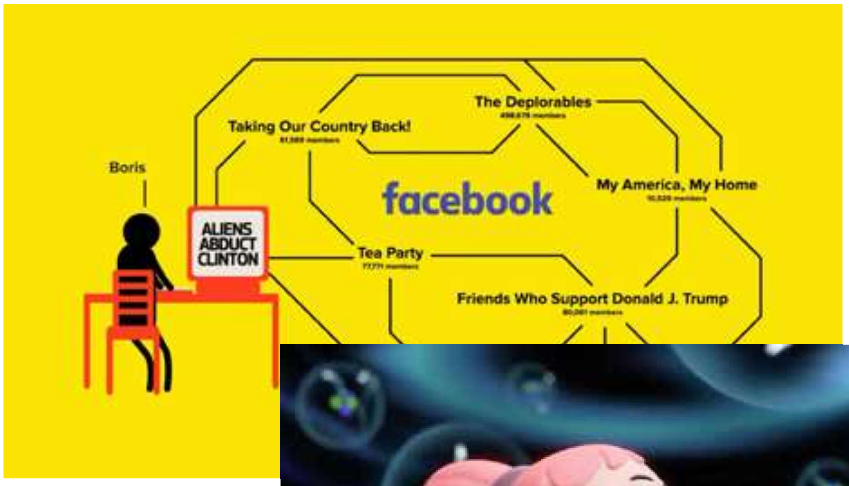
"Animation can explain whatever the mind of man can conceive". Walt Disney's immortalized definition of animation has inspired generations of artists to explore the potential of the visual languages ability to give life to the inanimate and to grasp and bend the nature of reality. Disney reflects the ambition to position animation as the centerpiece of imaginative expression – an ambition which has helped transform animation into a significant global industry. Through aesthetic and functional choices, the animator is able to condense, enhance, and even exaggerate meaning. For example, the use of a certain color palette and rendering of iconographic characters can break the barriers of what we normally perceive as reality and open our minds to assimilate ideas in a different way. This is what the acclaimed visual researcher Scott McCloud has called the 'amplification through simplification'[1]. When we abstract the idea of a concept in a simpler animated representation, we are not so much eliminating details as focusing on specific details in a form that could not easily be represented in the physical world. Stripping down a representational style to its essence amplifies the meaning in a way which realistic live action cannot achieve, and which is unique to the visual language of animation.

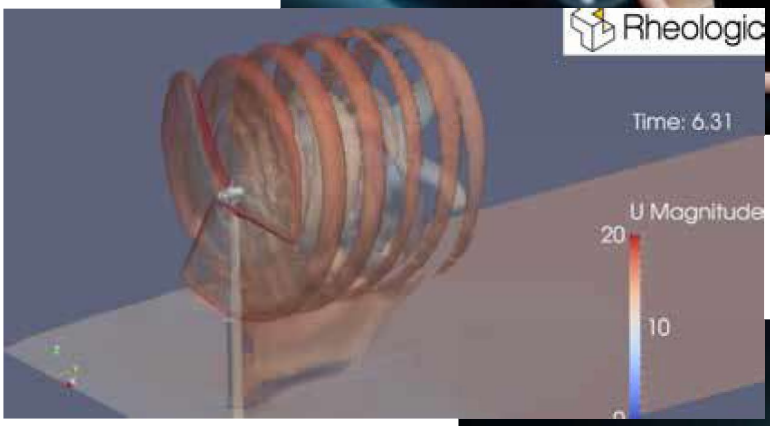
Alongside the huge success of animation in the entertainment and artistic industries, the last two decades has also seen a rise of so-called *functional animation* – animation used to portray factual information, through the creative lens of the animator. Using animation for other purposes than art and entertainment is not new, but ties back to some of the earliest uses of animation in e.g. propaganda films of the 1930's and later[2], and has been used for decades to make persuasive messages in the advertising industry. What is new, is an increased focus on the very fundamental, and more relevant than ever, question of how we can conceive, communicate, and debate the scientific knowledge to a broader audience through animation?

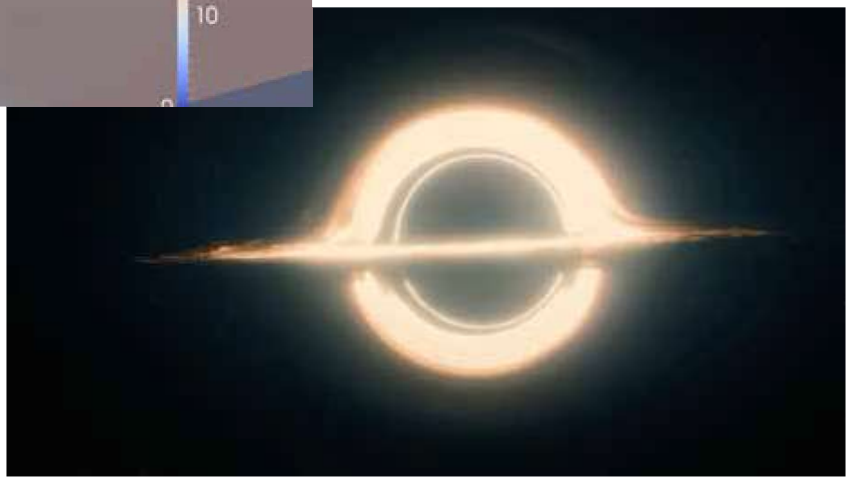
This calls for a new field, and potentially a new industry, for animators to pursue, which we have come to call science visualization – or SciVi for short. But unlike classic animation, with Disney's iconic 12 principles, and narrative storytelling models, SciVi has yet to establish its own set of principles and a community in which animators can collaborate with e.g. researchers, teachers, journalists, and decision makers to support fact-based knowledge dissemination in today's society.

Who's our audience?

On the surface, it is a fairly obvious point that any animation production should consider its target audience. However, with science visualizations the plot thickens, since we need to consider not just the audience, but also their respective prerequisites for the topic depicted. Studies have shown, that using animation for didactic purposes like e.g. explaining a complex topic or analyzing a set of data can increase the mental capabilities to reflect on the topic, even if the visualization somewhat distorts or exaggerate the realism of the topic[3]. This is especially true for novices, for whom the visual and dynamics of animation lowers the mental load of







Different intended roles of science visualizations. Wired's public oriented explainer video about the true structure behind fake news mechanism (top left). The'KvanteKarina' web-series, made by SDU/We Love People as a supplement to physics teaching in danish high schools (top right). Rheologic's animated and interactive simulations of wind aeroflow, used in peer to peer communication between engineers (bottom left), and the incredibly precise visualization of the 3D view of black hole from the movie 'Interstellar', later used in the grant proposals for funding scientific research (bottom right).

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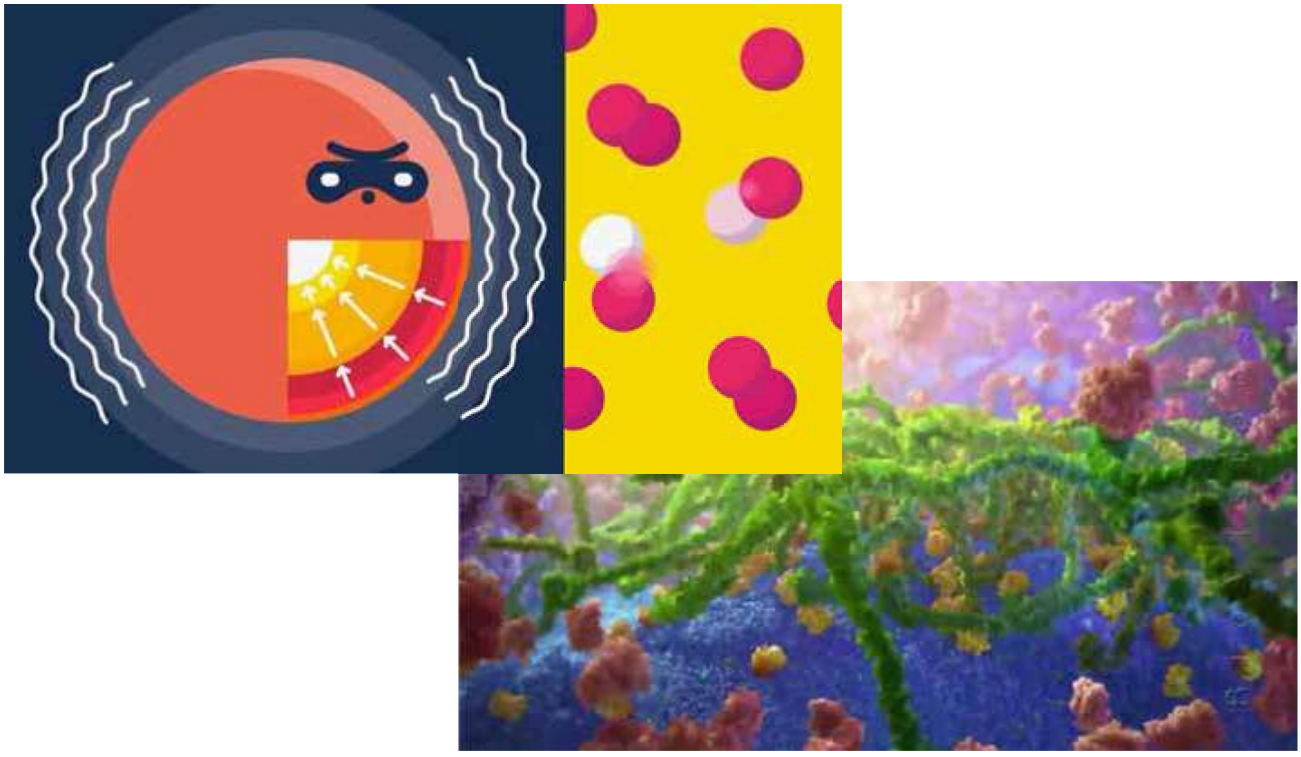
perceiving the information. On the other side of the spectrum, research has also shown, that domain experts can actually be inhibited from using too simple visualizations, leading them to a shallow reflection of the information[4]. Experts thus needs both more details, but also more control of the visualizations – eg. through interactive controls.

What this reveals is that Sci-Vi needs to both consider a continuum between novices and experts, but also consider whether the context of the animated visualization is to educate someone about something, or ignite a discussion between equally competent peers. Other contexts might aim for neither teaching or peer to peer, but rather to briefly clarify a topic to a broader audience using animation to 'spread the news'.

Science visualization might also move between these intents, starting as something used to precisely depict a phenomena for a mass audience, like the black hole visualization made for Christopher Nolan's sci-fi movie 'Interstellar', later used in scientific papers and grant proposals in a scientific context. These four archetypical contexts, from peer to peer to public communication, coupled with a consideration of balancing between novice and expert audiences are one of the core challenges for animators to consider when producing science visualizations.

Thinking or communication through SciVi?

But what about the actual content of the animated science visualizations? Does it follow the storytelling models of traditional animated films? We need to



Kurzgesagt's animated explainer video about fusion processes (left) clearly telling a story about the scientific topic, making the sun into e.g. a bloated character. This stands in opposition to Xvivo's beautiful and realistic rendering of the inner dynamics of a human cell, where the random an erratic movements still enable us to form narrative interpretations of chaos and order in a battle with each other.

consider whether science visualization is only meant as a piece of fixed communication, or whether it might also be considered a tool to think with. When 'only' used to communicate, we need to consider the principles of audience competencies and the context of the intended communication. But if we are aiming to use science visualizations as a tool to facilitate thinking more clearly about a given phenomenon, we need to consider how the depicted information might be used to enable entirely new ideas or realisations that are not inherent in the animation itself. Such situations are true, when e.g. science visualization is used in simulations. These are not reserved for scientist and domain experts, but might also be realized into so-called 'serious games' that utilizing a game setting for educational purposes.

The principles governing this 'temporal thinking' through science visualization can be understood as ensuring *apprehension* and *attention guidance*. That is to adjust the visuals so that any additional feature that is not directly useful for understanding should be left out from from the animation to not misdirect apprehension, and that the animation must be supported by clear visuals and interactive controls which guide the audience focus and enable individual pacing of the material[5].

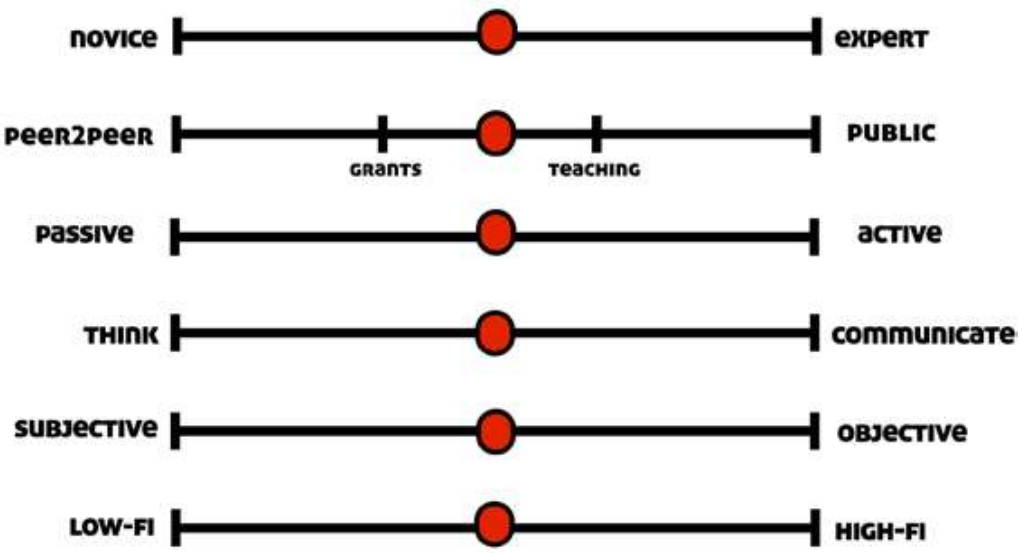
This not to say that thinking and communicating with animation are divided by a hard line in the sand, but rather that they present us with a continuum in which we must decide whether we are leaning towards telling a story or actively enabling the audience to form new knowledge.

Can Sci-Vi be objective?

Regardless of whether we are using Sci-Vi to communicate or to engage thoughts, an important final thing to consider is how we are wielding the narrative power inherent in a visual language such as animation. When we see a visual representation our brains start to rationalize, reason, and generalize the information into ordered, narrative structures to relate the past to the present, regardless of there being any story to begin with. Such narrative coherence is taught to help us navigate the world through 'plausible stories'[6]. However, this makes us very susceptible to form false narratives - especially when the facts portrayed are distorted or simplified. While some animated science videos clearly depict a distorted version of reality for narrative purposes, other strive to portray as exact an animated version of the real world as possible. But even then, our narrative mind takes over, and begins to interpret what we see and form stories.

This shows the great responsibility for visual storytellers doing science visualizations: to understand what we can never be fully objective when we portray the sciences through visual means. Thus, we must be very transparent in how we use animations to create narrative and visual spaces. Science visualization is not about presenting an exact picture of how reality looks, but rather an explanation of what it means.

By accepting that Sci-Vi can never be 100% objective in its pursuit to visualize the sciences, we can better embrace it and use it as a creative constraint in designing visualizations which adheres to the facts



The six principles for an emerging SciVi community to consider. 1) The competencies of the audience 2) The context of use for the visualization. 3) Whether there is ways to active investigate the material. 4) Whether the material is made to communicate or to facilitate new thoughts. 5) What level of objectivity to strive for, even though full objectivity is near impossible. 6) What level of graphical and animated fidelity is ideal to use when considering the other principles?

of reality, while leveraging the potential of animation to show not just facts about reality, but the essence of reality.

Should Sci-Vi look pretty?

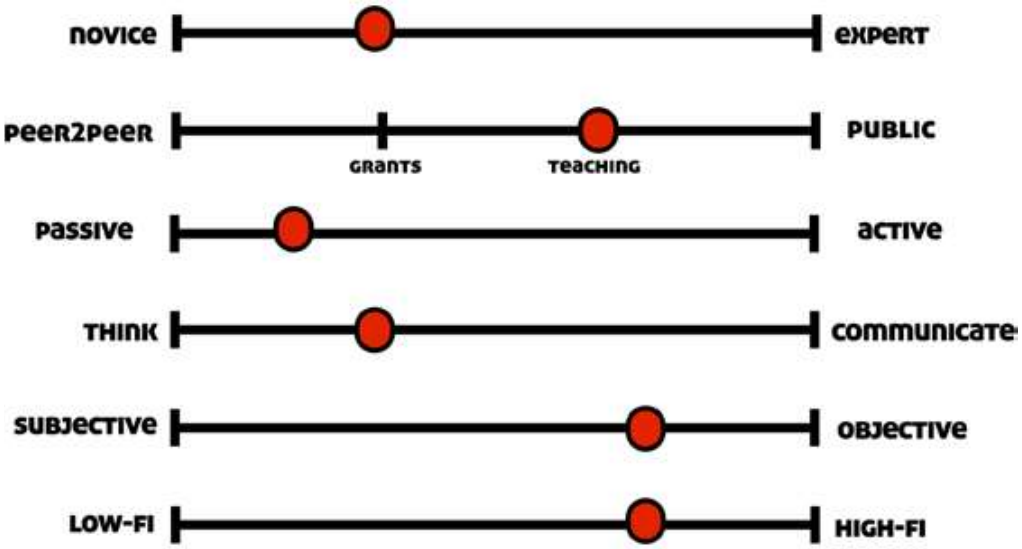
Last but not least, animation is no cheap form of communication to produce. Many existing examples of great Sci-Vi productions are fortunate to have been sponsored by organizations such as TED-Ed or by specific project fundings, but for Sci-Vi to truly grow as a wide spread approach, we need to consider where we set the bar in terms of the expected quality. Do the visual fidelity always have to be as high as in visualizations made for e.g. cartoons and movies? Or can Sci-Vi compromise on visual fidelity in favor for producing more content?

The answer to this question is essentially one final continuum, between high and low fidelity animations of Sci-Vi. In some instances, we will need very detailed graphics and carefully in-betweened motions to successfully communicate or facilitate an understanding of the scientific phenomena. At other times, a few simple lines with some rough stop-motion movement and a voice over may be sufficient. It all ripples back towards the previous covered principles of science visualization, demanding that we carefully consider our audience, the context of use, the role of the visuals, and how objective or subjective we can allow our portrayal to be. This is the great beauty of our field: it is all based on choices. Choices that we need to remember to articulate, when collaborating between visual storytellers and scientists.

Animators unite and visualize the sciences!

If there is one thing we can conclude, about the state of science visualizations, it is that the field is still in a state of flux, and has yet to fully formalize itself as an industry. There are an increasing number of amazing productions being made, and the interest and awareness of visualizations in communicating and facilitating the sciences are higher than ever. But it is also evident, that most of the productions being made are produced by skilled animators and storytellers, who have come into the field by chance and built their repertoires along the way - based on gradual accumulation of individual experiences. This is all great, but for the field to evolve and emerge as an animation field on its own premises, the skilled individuals need to form a community of practitioners with an ambition to develop science visualization as a school of thought within the visual communications field. This article has discussed some of the principles such a community should consider, presented as a continuum of choices we make, more or less deliberately, when creating visualizations of scientific topics.

The difference between a continuum and a hard definition is that the continuum uses similarities to position items in relation to one another, while a definition seeks differences to separate items from each other. In my humble opinion, the field of science visualization does not at this time need a debate about hard definitions, but could win more on comparing notes, approaches, and choices made in their productions to explore which similar positions in the continuum of



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audiences, contexts, roles, modalities, and fidelities they, as a field, has explored until now. A Sci-Vi community should further develop such principles into its own language and traditions, and place themselves as an industry alongside the fields of arts and entertainment - utilizing the amazing shared language for storytelling that is animation.

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